

IN THE CLAIMS

1. (currently amended) A computer-implemented process for segmenting image data, comprising the process actions of:
 - inputting an image;
 - segmenting said image using a mean shift segmentation technique employing anisotropic kernels; wherein segmenting said image comprises:
 - initializing kernel data;
 - for each of a set of feature points, determining an anisotropic kernel with a spatial component and a related color component;
 - associating a mean shift point with every feature point and initializing said mean shift point to coincide with that feature point;
 - updating mean shift points by iterative anisotropic mean shift updates; and
 - merging vectors associated with feature points that are approximately the same to produce homogeneous color regions.
2. (original) The computer-implemented process of Claim 1 wherein the anisotropic kernels comprise a spatial/lattice component and a space dependent range/color domain component.

3. (original) The computer-implemented process of Claim 1 wherein the anisotropic kernels comprise a spatial/lattice component and a range/color domain component that is not space dependent.

4. (cancelled)

5. (currently amended) The computer-implemented process of Claim [[4]] 1 wherein initializing the kernel data comprises the process actions of:

transferring pixels of said image into multi-dimensional feature points, x_i ;

specifying an initial spatial domain parameter h_0^s and an initial range domain parameter h_0^r ;

associating kernels with said feature points;

initializing means of kernels as the value of said feature points associated with kernels; and

setting initial kernel bandwidth matrices in the spatial/lattice domain as the diagonal matrix $H_i^s = (h_0^s)^2 I$ and in the range/color domain setting $h^r(H_i^s) = h_0^r$, where I is the identity matrix.

6. (currently amended) The computer-implemented process of Claim [[4]] 1, wherein for each of a set of feature points, determining an

anisotropic kernel with a spatial/lattice component and a related range/color component, comprising the process actions of:

- for each feature point x_i , searching the neighbors of said feature point x_j , $j=1, \dots, n$ to obtain all feature points that satisfy the constraints of the kernels;
- iteratively updating a bandwidth matrix of the anisotropic kernel in the spatial domain,
- modulating the bandwidth of the anisotropic kernel in the spatial domain; and
- modulating the color tolerance of the related color component.

7. (original) The computer-implemented process of Claim 6 wherein the constraints of kernels are defined by:

$$k^2(g((x_i, x_j, H_i^S)) < 1; k^r \left\| \frac{x_i - x_j}{h^r(H_i^S)} \right\|^2 < 1$$

where H_i^S is the spatial/lattice bandwidth matrix and h^r is the range/color bandwidth parameter.

8. (original) The computer-implemented process of Claim 6 wherein the bandwidth matrix H_i^S is updated as:

$$H_i^S \leftarrow \frac{\sum_{j=1}^n \left\| \frac{x_i' - x_j'}{h^r(H_i^S)} \right\|^2 (x_j^S - x_i^S)(x_i^S - x_j^S)^T}{\sum_{j=1}^n \left\| \frac{x_i' - x_j'}{h^r(H_i^S)} \right\|^2}.$$

9. (original) The computer-implemented process of Claim 8 wherein the range/color bandwidth parameter $h^r(H_i^s)$ is updated as:

$$h^r(H_i^s) \leftarrow \sqrt{\frac{\lambda^r}{\lambda}} \cdot h^r(H_i^s)$$

10. (original) The computer-implemented process of Claim 6 wherein the segmentation is a single image segmentation and wherein modulations are applied to exaggerate eccentricity and modify scale.

11. (original) The computer-implemented process of Claim 6 wherein the segmentation is video segmentation and wherein modulations are applied for exaggerating eccentricity, scaling static segments, and overall scale.

12. (currently amended) The computer-implemented process of Claim [[4]] 1, wherein updating the mean shift points by iterative anisotropic mean shift updates, comprises the process actions of:

for each mean shift point $M(x_i)$,

determining the neighboring feature points x_i ;

calculating a mean shift vector $M(x_i)$ summing over all the neighboring mean shift points; and

updating the mean shift points;

until the change in the mean shift points is less than a specified amount.

13. (original) The computer-implemented process of Claim 12 wherein the mean shift vector is calculated as:

$$M_v(x_i) = \frac{\sum_{j=1}^n (x_j - M(x_i)) \left\| \frac{M(x'_i) - x'_j}{h'(H_j^s)} \right\|^2}{\sum_{j=1}^n \left\| \frac{M(x'_i) - x'_j}{h'(H_j^s)} \right\|^2}.$$

14. (original) A system for segmenting image data, comprising:

defining an anisotropic kernel of influence for each pixel in an image, wherein said kernel defines a measure of intuitive distance between pixels, where distance encompasses both spatial/lattice and range/color distance; and

assigning to each pixel a mean shift point initialized to coincide with said pixel;

iteratively moving each mean shift point upwards along the gradient of the kernel density function defined by the sum of all the kernels until they reach a stationary point; and

considering pixels that are associated with the set of mean shift points that migrate to the approximately same stationary point to be members of a single segment.

15. (original) The system of Claim 14, further comprising:

combining neighboring segments.

16. (original) The system of Claim 14, further comprising eliminating segments that contain less than a specified number of pixels.

17. (original) The system of Claim 14 wherein the image is a portion of video data and wherein distance further comprises temporal distance.

18. (currently amended) A computer-readable medium encoded with ~~[[having]]~~ computer executable instructions for segmenting image data, said computer executable instructions comprising:

inputting image data; and

segmenting said image data using a mean shift segmentation technique employing generally elliptical kernels wherein the computer-executable instruction for segmenting said image data comprises sub-instructions for:

initializing kernel data;

for each feature point, determining a kernel being a product of kernels with at least one of these kernels being elliptical;

associating a mean shift point with every feature point and initializing said mean shift point to coincide with that feature point;

updating mean shift points by an iterative anisotropic mean shift update; and

merging vectors associated with feature points that are approximately the same to produce homogeneous color regions.

19. (original) The computer-readable medium of Claim 18 wherein an elliptical kernel comprises a spatial component.

20. (original) The computer-readable medium of Claim 18 wherein a non-elliptical kernel comprises a color domain component.

21. (original) The computer-readable medium of Claim 18 wherein the computer-executable instruction for segmenting said image data using a mean shift segmentation technique, comprises a sub-instruction for defining the shape of a elliptical kernel as $\lambda D A D^T$ where λ defines the overall volume of the kernel, A defines the relative lengths of the axes, and D is a rotation matrix that orients the kernel in space and time.

22. (original) The computer-readable medium of Claim 21 wherein the computer-executable instruction for segmenting said image data using a mean shift segmentation technique, further comprises a sub-instruction to modify the shape of an elliptical kernel by varying λ , A or D .

23. (original) The computer-readable medium of Claim 19 wherein the image is a portion of video data and wherein the generally elliptical kernel further comprises a time component.

24. (original) The computer-readable medium of Claim 22 wherein by varying λ the spatial size of the kernel is adjusted.

25. (original) The computer-readable medium of Claim 22 wherein by varying A the shape of the kernel is varied.

26. (original) The computer-readable medium of Claim 25 wherein segmentation to segment elongated regions is encouraged by defining A as a diagonal matrix of Eigen values which is normalized to satisfy:

$$\prod_{i=1}^p a_i = 1$$

where a_i is the i^{th} diagonal elements of A , and $a_i \geq a_j$, for $i < j$; and wherein

the smaller Eigen values of A are diminished by: $a_i = \begin{cases} a_i^{3/2} & a_i \leq 1 \\ \sqrt{a_i} & a_i > 1 \end{cases}, i = 2, \dots, p$.

27. (original) The computer-readable medium of Claim 25 wherein larger segments for static objects are created by computing a scale factor s_i as

$$s_i = \alpha + (1 - \alpha) \prod_{i=1}^{p-1} d_1(i)^2$$

where d_1 is the first Eigen vector in D , which corresponds with the largest Eigen value a_1 . $d_1(i)$ stands for the i^{th} element in d_1 , which is the x , y and t component of the vector when $i = 1, 2, 3$, respectively, and α is a constant between 0 and 1;

setting α to 0.25;

changing A to $a_i' = a_i \cdot s_i, i = 2, \dots, p$;

modifying A as $a_i = \begin{cases} a_i^{3/2} & a_i \leq 1 \\ \sqrt{a_i} & a_i > 1 \end{cases}, i = 2, \dots, p$ or modifying A as

$$s_i = \alpha + (1 - \alpha) \prod_{j=1}^{p-1} d_j(i)^2; \text{ and}$$

changing global scalar λ as

$$\lambda' = \lambda \prod_{i=1}^p \frac{a_i}{a_i'}.$$

28. (original) The computer-readable medium of Claim 19 wherein said spatial kernel has a constant profile, $k^s(z) = 1$ if $|z| < 1$, and 0 otherwise.

29. (original) The computer-readable medium of Claim 20 wherein said color component uses an Epanechnikov kernel with a profile $k^r(z) = 1 - |z|$ if $|z| < 1$ and 0 otherwise.